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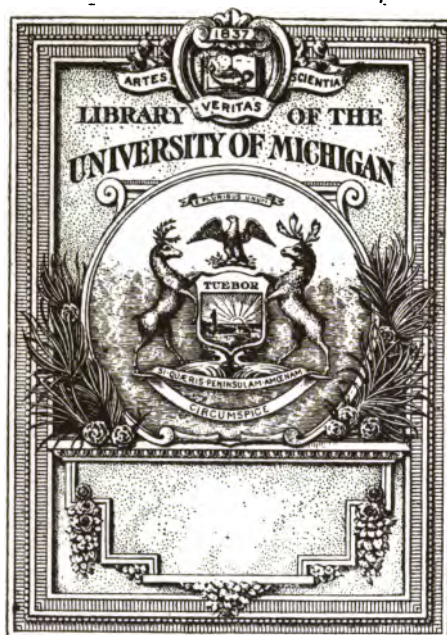
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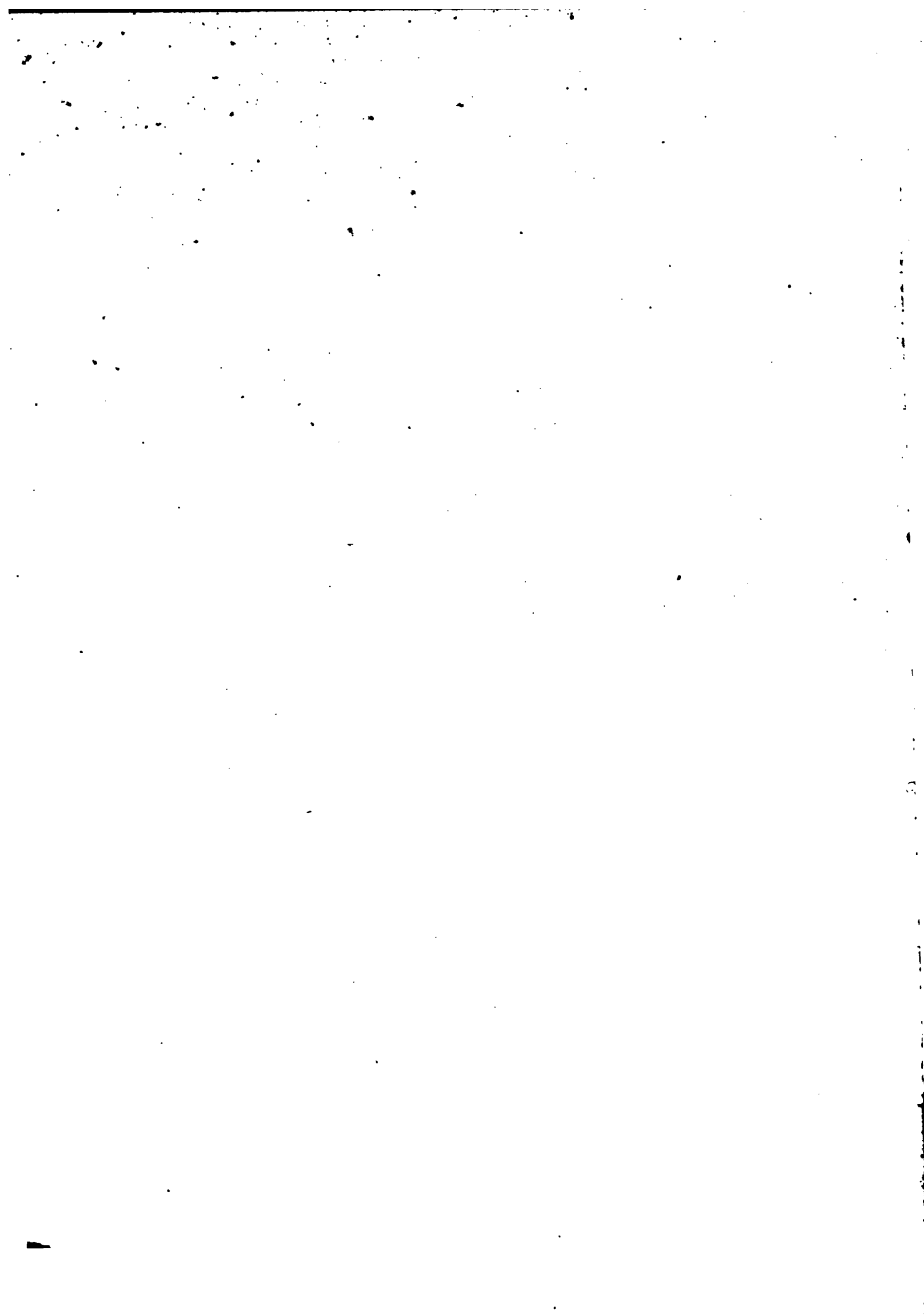
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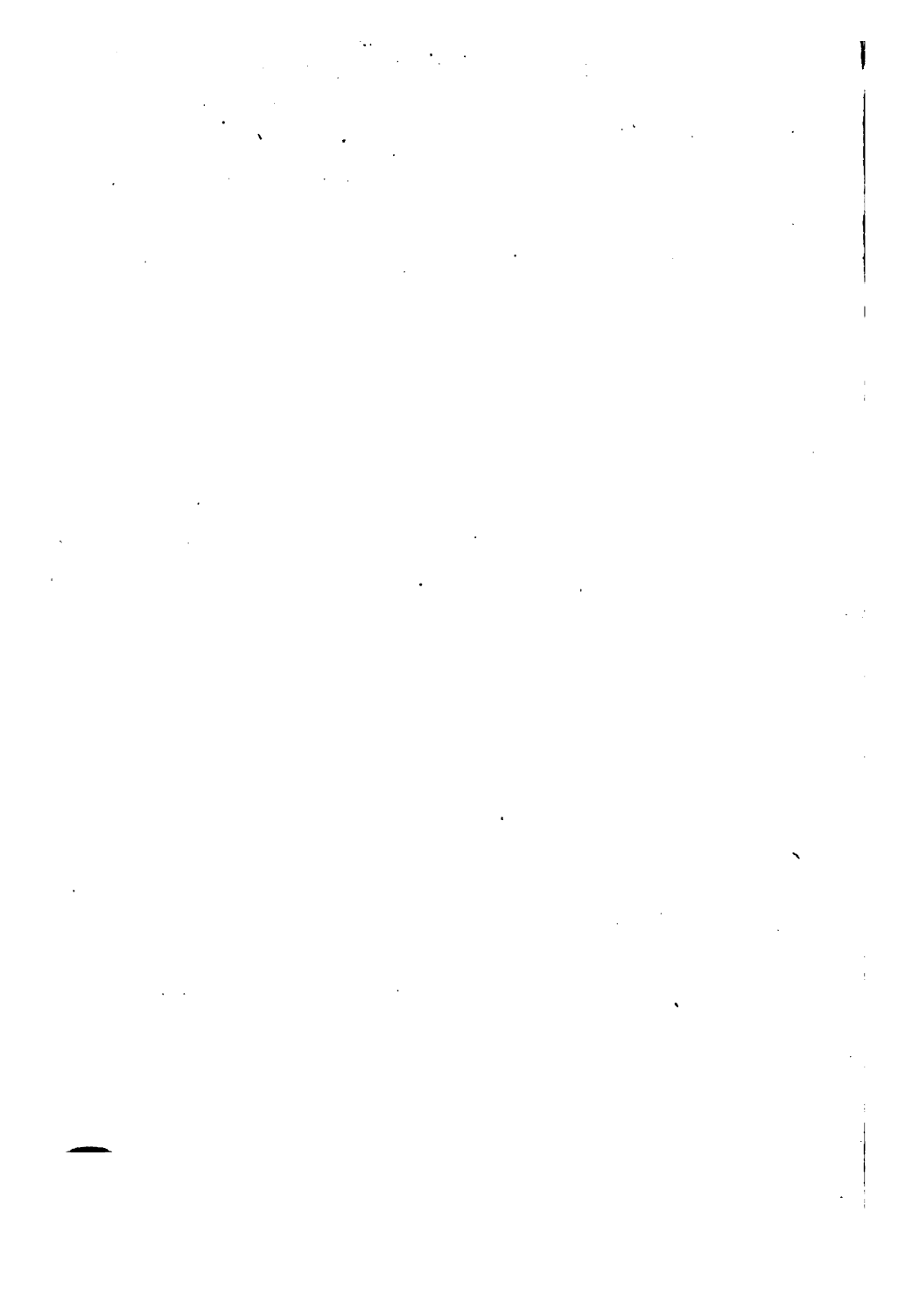
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CHEMICAL TESTS FOR MINERALS



BY ARTHUR J. ^{*Young*}BURDICK

Author of "The Mystic Mid-Region—Deserts of
the Southwest," "The Prospector's Man-
ual," "Valuable Minerals, How to
Find and Know Them," etc., etc.



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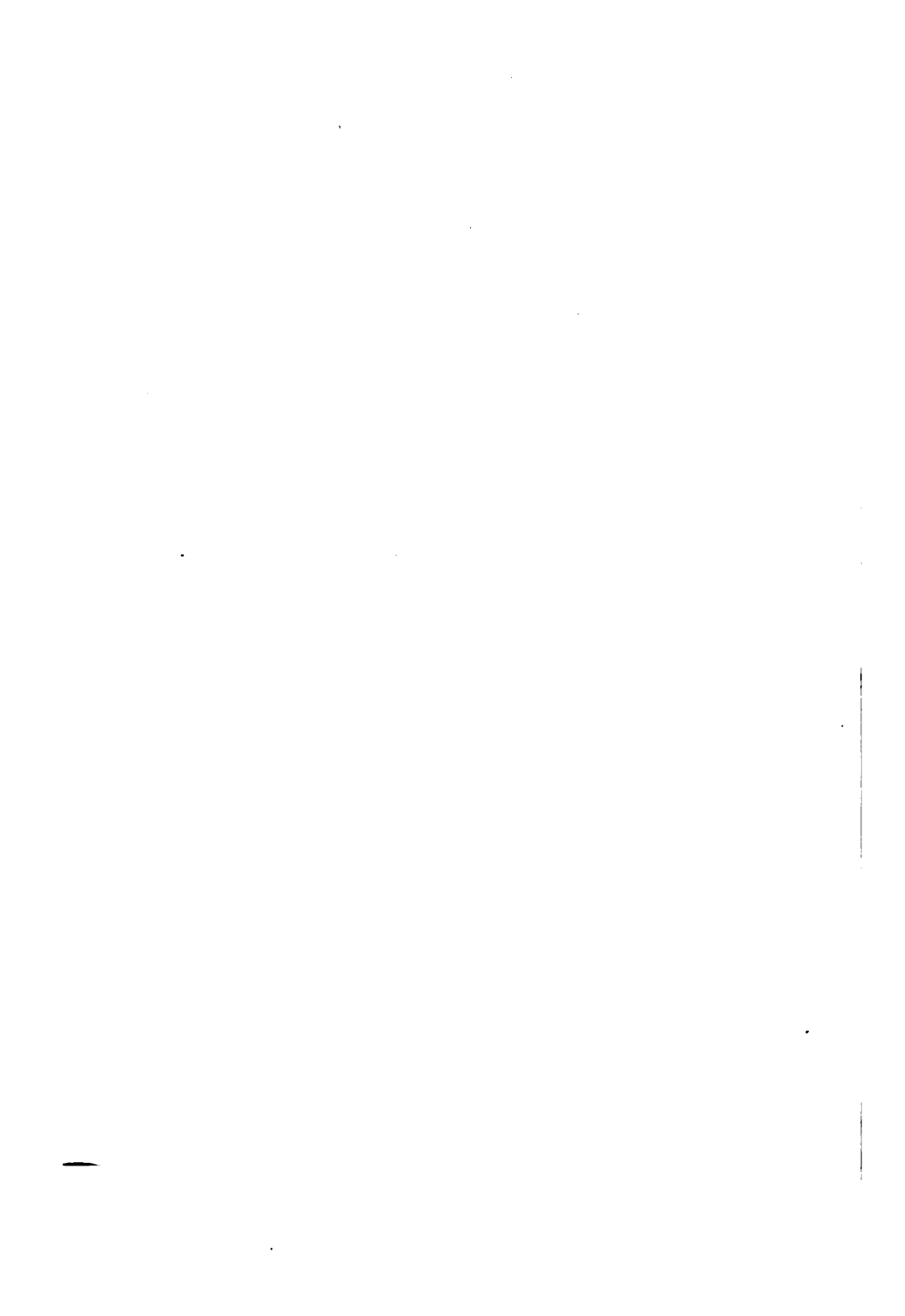
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INTRODUCTION

The prospector who goes into the field unprepared to make identifying tests of the rocks and ores which he may encounter is sadly handicapped and his chances for success are few.

There are a number of methods for identifying ore which are simple and inexpensive. In a little book entitled "Valuable Minerals, How to Find and Know Them," the author of this work has told how to classify ores by means of weight, hardness, color, streak, luster, etc. By these means one may identify many of the valuable ores.

It often happens, however, that two or more minerals are combined in one ore. Also, there is such a similarity in the ores of different mineral that it is difficult, sometimes, to distinguish between them and the prospector feels the need of further assistance.

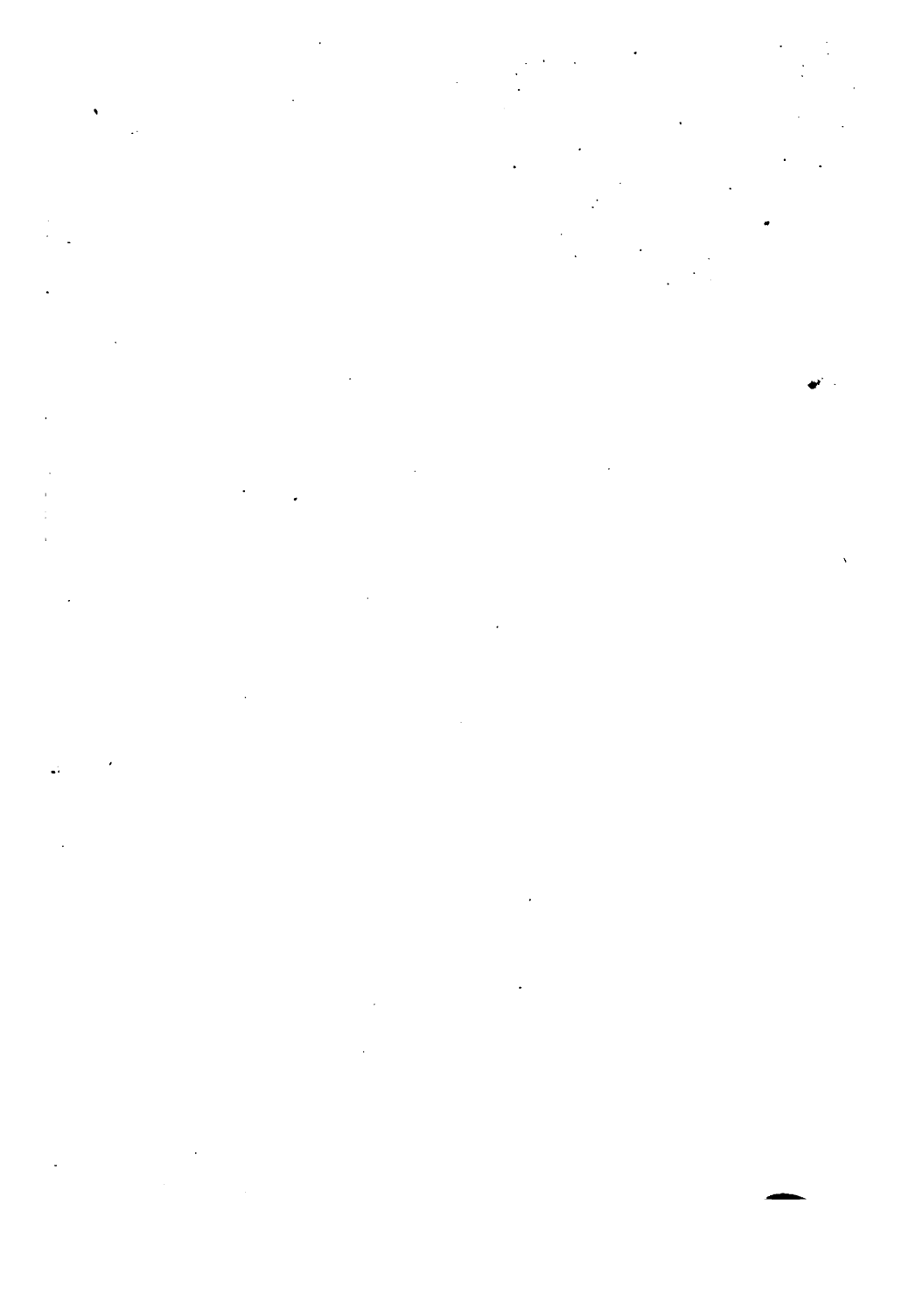
To depend upon the assayer to identify the rocks and ores of his finding is not only expensive, but it occasions delay which is still more awkward and costly.

It is to assist the seeker for mineral wealth to a ready determination of his discoveries that this book is written.

A small field laboratory and an inexpensive blowpipe outfit are both time and money savers to the prospector. With an outfit of chemicals he can call to his aid Nature—the master assayer—one who makes no mistakes, and one who will not fail him if he but does his part.

The tests given in this work are qualitative. For quantitative determination the prospector should always consult the assayer. The main point with the prospector in the field is to learn whether or not he has actually located mineral of value. The assayer will tell him whether or not the ores are of sufficient richness to pay to operate.

That the careful study of this treatise and a painstaking following of the formulas herein given will lead the persistent and faithful prospector to satisfactory results is the belief of the writer.





CHAPTER 1.

PRELIMINARY STEPS.

Before proceeding to the formulas given in this book, the prospector should familiarize himself with some of the principles which govern the use of chemicals, with the symbols by which elements and reagents are distinguished, with atomic weights, the specific gravity, hardness, etc., of the various minerals.

There are no chance propositions in nature. She always works on definite lines and follows established laws.

The same compound is always made up of the same constituents, combined with the same definite proportions.

Each element has its combining weight, always the same, although the same two elements may form more than a single combination, as for example, oxygen and nitrogen form no less than five compounds.

It will be seen by referring to the table of mineral elements, that each element has an

atomic weight given it, which is its combining weight. Hydrogen is the standard for comparison, and its atomic weight is placed at 1. This is the lightest known element. The atomic weight of oxygen is placed at 16. The constituents of water are two atoms of hydrogen to one atom of oxygen. The symbol expressing this combination is H_2O , signifying that two parts of hydrogen are combined with one part oxygen in the substance called water.

If one element unites with another in more than one proportion, these proportions will all be multiples of its combining weight.

For example: The atomic or combining weight of silver is 108; that of chlorine 35.5. These having a chemical affinity combine in equal atoms producing $AgCl$, or silver chloride. By weight the combination represents 108 of silver to 35.5 of chlorine. No other weight proportions could be represented. If three atoms of silver and five atoms of chlorine were mixed in a solution three atoms of silver and three atoms of chlorine would combine and the remaining two atoms of chlorine would remain in the solution not taken up.

The combining weight of a compound like-

wise remains unchangeable. For example: Water contains two parts of hydrogen and one part of oxygen. Its numerical weight is, therefore 2 plus 16, equals 18. Water combines with many other substances, but its combining weight always is 18.

Realizing the fixedness and reliability of the elements we will proceed to the consideration of the reagents used in determining the ores.

REAGENTS is the name given to the materials used in securing analytical reactions. Some of these, in making tests, are used to form new combinations, others to separate existing combinations.

Minerals are classified as metals and non-metals, as, for example, gold, silver, copper, etc., are metals; oxygen, hydrogen, nitrogen, etc. are non-metals. In analytical classifications some minerals not generally termed metals are called metals, as, for example, arsenic, selenium, etc.

It will be observed that there are a number of suffixes used for the same substance, as "sulphuric acid," and sulphurous acid," "sulphate," "sulphide," etc. An explanation of these suffixes is necessary.

"Ous" indicates a low per cent acid; "ic" a high

per cent acid; "ite" signifies a salt from an "ous"; "ate," a salt from an "ic"; "ide" indicates an element combined with a non-metal. As an example: "Silver chloride" is the metal silver combined with the non-metal chlorine. "Hydro" as a prefix indicates that only a part of the hydrogen of an acid is displaced, the presence of the remainder being indicated by the prefix "hydro." As an example: When all the hydrogen of sulphuric acid is displaced by sodium the substance is called "sodium sulphate." If only one of the two combining weights of hydrogen is displaced the presence of the metal and the remaining hydrogen is indicated in the name as "hydro-sodium sulphate."

In testing for minerals with chemicals there are reagents adapted to single mineral tests and there are "general reagents" which will precipitate a group of minerals.

When the prospector is practically assured that he has the ore of some particular mineral, he may use the reagent or reagents which will give him results on that particular mineral. If, on the other hand, he believes that he has rock containing some mineral, but he does not know what that mineral is, he will find it necessary to

make a general analysis and will first use the group reagents, then, if a precipitate or coloration results, under any one of the several groups he may, by the use of specific reagents, determine what particular mineral or minerals the ore contained.

Before proceeding to the tests a word regarding the outfit necessary for the work is timely.

As a basis for his work the following will answer the purpose of the prospector:

1 iron mortar and pestle—for field work one weighing not more than 1 1-2 or 2 pounds will do.

1 small alcohol lamp.

Pocket magnet.

6 test tubes 6 inches in length and 3-4 inch in diameter.

Magnifying glass.

1 four-inch glass funnel, smooth inside.

One or two 4-oz. graduates or beakers.

1 pipette or Burette tube graduated to cubic centimeters.

100 sheets 6 inch round filter paper.

1 horn spoon or six-inch gold pan.

1 large gold pan.

2 or 3 4-inch porcelain dishes.

The following chemicals are absolutely necessary: Nitric Acid, Hydrochloric Acid, Sulphuric Acid, Ammonia, Ammonium Sulphide, Ammonium Carbonate, Iron Sulphide, fused.

Other chemicals will be needed for the various tests and may be purchased from time to time as the need requires. The outfit should also include red and blue litmus paper, denatured alcohol for the lamp, some metallic zinc, copper and tin. A glass rod for stirring solutions will also be a convenience.

CHAPTER II.

DISSOLVING THE ORES

Different minerals are soluble in different elements. In putting the powdered ore into solution it is important that the right solvent be used. The form of the precipitate depends on the resolvent reagent used. Some mineral substances are soluble in cold water; others in hot water. Still others require a dilute acid. Others yield only to a strong acid. A few minerals are soluble only in aqua regia and some do not yield even to that, but require fusing.

First thoroughly pulverize the ore. It should be fine enough to pass through a 60-mesh sieve.

Take a small portion and place in a test tube. Add cold water. Note if effervescence takes place. If so, this indicates that a portion of the substance is solvent in water. Next boil the substance a few minutes by holding the tube over the alcohol flame. If none of the powder is dissolved the mineral is not soluble in water.

To learn if any has dissolved, filter and drop a few drops of the filtrate upon a watch glass and heat very gently until evaporated. A residuum on the glass shows that some of the substance has passed into solution, and the liquid should be set aside for further testing.

The portion insoluble in water is now treated with dilute hydrochloric acid and boiled. Again watch closely for symptoms of effervescence. If the dilute acid does not entirely dissolve the powder, let settle, pour off the clear portion and add strong hydrochloric acid and give it prolonged boiling. If the substance is entirely dissolved by this process the two acid solutions may be poured together unless it is seen that by mixing a precipitate results, in which case they must be tested separately.

If the substance is not entirely dissolved, it would suggest that some of the minerals insoluble in simple acids are there, such as platinum, sulphides of cobalt, nickel or mercury, and the residue may be boiled in aqua regia.

This should be done in a porcelain dish and the substance boiled to dryness to expel the acids. Then add water and heat, first letting the

dish cool. If no residue is apparent the solution may be mixed with the hydrochloric acid extract. If there is an insoluble residue, filter off the liquid and treat the residue by fusion as follows:

Dry the residue and mix it with about four times its weight of sodium carbonate and potassium cyanide, added to a little potassium nitrate. If lead sulphite or silver chloride is present, fuse in a porcelain crucible, otherwise a platinum crucible may be used.

After fusion, boil the substance in water until no further reduction takes place, then filter.

The water solution above mentioned is tested for the following acids: arsenic, chromic, hydrofluoric, hydrochloric, phosphoric, silicic, sulphuric. The acid solutions may be examined for specific minerals or put through a general test as set forth in Chapter III.

CHAPTER III.

CHEMICAL TESTS FOR MINERALS

Minerals for the purpose of analysis are divided into five groups. Each of the first four groups has a group reagent, or chemical, which will precipitate all the metals in that group. The minerals in group V have no general reagent, separate tests being required for each mineral.

It must be remembered that two or more minerals are sometimes associated in the same ore. Gold, silver and copper frequently are so associated. Silver and lead often go together. Gold, platinum, palladium, ruthenium, and radium often associate in platinum ores, gold nearly always being found with platinum. Nickel and cobalt are closely associated. Iron and copper and iron and gold combinations are common.

It will be noted that some of the minerals are classed in two groups. This is because some of the combinations of these metals are such

that a portion of them pass out of the one group into the other.

In analyzing an ore by the group method it should be tested by beginning with Group I, next Group II, and so on, in numerical order, for the group reagent only separates the metals of the group from those in the groups that come after, not those which come before. For example, ammonium sulphide, the reagent for Group III, will precipitate all the minerals of Groups I and II as well as III, omitting only those of Groups IV and V, therefore if this were used first a precipitate might indicate any one or more of the minerals in all three groups, leaving the operator little wiser for his pains.

The substance to be treated should first be thoroughly pulverized in the mortar. A small amount of the pulverized ore, say a teaspoonful, is sufficient for a test. Dissolve the ore as instructed in the previous chapter and filter. Prepare the filter as follows:

Fold the filter paper into half, and then at right angles into half again. Open this into a cone, with one thickness of paper on one side and three on the other. Place the cone in the glass funnel smoothly pressed against the sides

of the glass and moisten with distilled water. See that the paper fills the funnel with no air spaces underneath. If the paper, folded as above, does not fit the funnel, change the fold so that it will fit.

Gently pour the solution from the porcelain dish into the filter, rinsing all the sediment from the porcelain dish into the filter. When the liquid has passed through the filter, gently wash down with warm water to get all soluble matter through. You are now ready to begin the group tests. The minerals are grouped as follows:

GROUP I—Silver, Mercury, Lead, Thallium, Tungsten.

GROUP II—Mercury, Lead, Bismuth, Copper, Cadmium, Antimony, Arsenic, Tin, Gold, Platinum, Ruthenium, Palladium, Osmium, Iridium, Tellurium, Selenium, Molybdenum.

GROUP III—Aluminum, Chromium, Iron, Nickel, Cobalt, Manganese, Zinc, Beryllium, Zirconium, Thorium, Cerium, Scandium, Yttrium, Lanthanum, Ytterbium, Titanium, Niobium, Uranium, Indium, Thallium, Vanadium.

GROUP IV.—Barium, Strontium, Calcium.

GROUP V.—Ammonium, Sodium, Potassium, Magnesium, Lithium, Rubidium, Caesium.

Should the prospector find an ore which, from heft and general appearance leads him to believe it contains minerals of value, yet he is unable from the appearance of the ore to identify the mineral or minerals which it contains, he will need to put the ore through the general qualitative analysis to satisfy himself regarding its contents. The process is here explained.

He will first test for ores of Group I. To the filtered solution of the ore, add slightly diluted hydrochloric acid, drop by drop—a medicine dropper may be used—watching the solution to note if any precipitate results. If so, continue to add the acid until no new precipitate is formed, and then add a few more drops to insure complete precipitation. Warm the mixture over the alcohol lamp, then set aside to cool. When cool filter. The solution now contains any minerals of Groups II, III, IV and V. The minerals of Group I are in the filter paper, being the precipitate resulting from the addition of the hydrochloric acid. This may be one or all of

the minerals of the group, which are silver, lead, mercury, thallium and tungsten.

This precipitate should now be thoroughly washed in cold water, the minerals of this group being insoluble in cold water. After washing add more water and boil, then filter. The filtrate or solution will contain the lead, if any in the ore, as lead is soluble in hot water. When the solution is cool the lead will be deposited in white, needle-like crystals.

The residue which was left in the filter paper is treated while still on the filter with a little ammonia. This will dissolve the silver chloride, if any. This will pass through the filter paper and mercury, if any, will be changed from white mercuric-chloride into a black mercuric salt.

The solution containing the silver is now treated with nitric acid which precipitates the silver as white silver chloride. The black residue, mercuric salt, may now be dissolved in aqua regia, the solution neutralized by ammonia, and the mercury precipitated upon a piece of bright metallic copper introduced into the solution.

Should there be any white precipitate resulting from the introduction of hydrochloric acid,

which does not test up as silver, lead or mercury, it may be supposed to be tungsten and may be proven by boiling the precipitate in hydrochloric acid and adding metallic zinc. A blue color resulting is proof that it is tungsten.

A black precipitate not testing as one of the above minerals is probably thallium. Prove by adding to the solution potassium iodide. A bright golden yellow precipitate of thallic iodide results. This is soluble in strong sulphuric acid, white lead chloride not being dissolved by this reagent.

Thallium is one of the rare metals, specific gravity 11.9, and has little commercial value.

Having thus disposed of the minerals of Group I, the operator will now proceed to test the solution for metals of Group II.

In this test sulphuretted hydrogen is passed through the solution that being the general reagent for the minerals of this group. This is accomplished by the use of the sulphuretted hydrogen bottle. This bottle may be prepared as follows: Take a large-mouthed bottle holding at least 8 ounces. Fit with a rubber stopper with two holes. Into one hole introduce a glass tube just long enough to project 3-4 of an inch

both below and above the stopper. Into the other hole fit a tiny glass funnel, the tube of which should extend two-thirds the length of the bottle.

Into the bottle put two table-spoonsful of iron sulphide, fused, through the funnel pour sufficient water to slightly submerge the bottom of the funnel tube. Attach to the projecting tube one end of a rubber hose, say two feet long. In the other end of the hose should be another glass tube the end of which should be submerged in the liquid to be tested. Now pour a small quantity of sulphuric acid into the bottle, through the glass funnel. Sulphuretted hydrogen gas is formed, which passes through the rubber hose into the liquid in the beaker, causing it to bubble.

Having prepared the bottle the operator is ready to proceed.

The minerals of Group II are subdivided into two sections: 1, those whose sulphides are insoluble in ammonium sulphide. These are bismuth, cadmium, copper, lead and mercury, and, 2, those whose sulphides are soluble in that reagent, these being antimony, arsenic, gold, platinum, tin.

Before introducing the sulphuretted hydrogen gas, the solution should be acidified by the addition of a few drops of hydrochloric acid. Then pass through the solution the sulphuretted hydrogen, let operate so long as the solution bubbles. The precipitate resulting from this operation contains the metals of this group. This solution should be divided into two parts for testing for metals of the two divisions.

The precipitate should be thoroughly washed to remove all the hydrochloric acid and soluble chlorides and then transferred to a porcelain dish with as little water as possible. Add an equal portion of nitric acid and boil until the contents are as nearly dissolved as possible. Dilute and add a few drops of sulphuric acid. Let cool and filter.

The filtrate contains the nitrates of any bismuth, cadmium and copper which may be contained in the ore. Add an excess of ammonium hydrate and boil. The residue in the filter contains mercury sulphide (black) or mercurous sulphide (white) and the lead precipitate, also white.

The filtrate on being boiled, as directed above, will give a white precipitate of bismuth, if

present in the mineral. Dissolve this white precipitate in hydrochloric acid and drop the solution, a drop at a time, into a tube or beaker of water. If a white precipitate results, this confirms the test, proving bismuth.

The solution from which the bismuth was precipitated will contain any cadmium or copper contained in the ore.

A blue solution indicates copper. If copper shows, add potassium cyanide until the solution is colorless. Then boil this in a solution of ammonium acetate and filter. To the solution add potassium chromate. A yellow precipitate is lead. Dissolve the residue in a small portion of aqua regia and boil to dispel the chlorine. Neutralize with sodium hydrate. Acidify by the addition of hydrochloric acid. Immerse in the solution a piece of clean copper and if mercury is present it will give a silvery coating to the copper.

This disposes of the minerals of division I of Group II.

Take the portion of the solution set aside for testing for the second division of Group II, gently warm with ammonium sulphide and filter. The residue contains the undissolved sulphides of

division 1 of the group. The solution will contain any salts of arsenic, antimony and tin that may be contained in the ore. Add water and introduce hydrochloric acid, drop by drop until the sulphides are precipitated. Filter and wash as in the other operation. Place the precipitate in a test tube, add a small portion of hydrochloric acid and boil to dispel the sulphuretted hydrogen, then dilute and filter. The residue contains the arsenic sulphide and sulphur. The solution will hold the antimony, if any, and the tin. To test for antimony place a small particle of zinc on a piece of platinum foil and drop a few drops of the solution thereon. Antimony is indicated by a black stain.

In the remaining solution introduce the platinum foil and a piece of zinc. The tin and antimony will be precipitated. Boil the precipitate in hydrochloric acid and filter. Add a small quantity of mercuric chloride to the filtrate. Tin will be deposited as a white precipitate.

GROUP III.

Like Group II, the minerals of this group are divided into two classes owing to their behavior under treatment.

The solution remaining from previous operations contains the minerals of Groups III, IV and V. The general reagent of the group is ammonium sulphide, which, if added to the solution will precipitate all the metals of the group. However, it simplifies the analysis to separate a portion of the metals—those of division 1, and consider these first, then to proceed with the remaining metals of the group, in division 2, separately.

To the solution add a liberal quantity of ammonium chloride and bring the solution to a boiling point. Then add, a little at a time, ammonium hydrate until precipitation is complete. Again heat to the boiling point and filter. The precipitate will contain, if such be in the ore, aluminum, chromium and iron. After thoroughly washing, put a portion of the precipitate in a test tube and add a little water. To this add sodium peroxide and boil until effervescence ceases, then filter. The filtrate consists of sodium chromate and sodium aluminate. Divide the filtrate into two portions. Acidify one portion with acetic acid. A yellow color indicates chromium. To this add a strong solution of potassium dichromate. The chromium oxide is precipitated in the form of red, needle-like crystals.

Acidify the second portion with dilute nitric acid and add ammonium hydrate. Aluminum will be thrown down as a white precipitate.

The residue from the original filtration contains the iron. Dissolve this in hot hydrochloric acid, diluted, and add potassium ferro-cyanide. A blue color confirms iron.

The second division of Group III contains the minerals manganese, zinc, nickel and cobalt.

Pass sulphuretted hydrogen through the solution remaining after having precipitated the metals of division 1 of Group III. Slightly warm and filter.

The precipitate consists of the four metals of the group, or as many of them as may be contained in the ore being tested. Dissolve the solution in hot, dilute hydrochloric acid with a small portion, if the precipitate is black, of potassium chloride. Boil to dispel the chloride and add sodium hydrate in excess. Again boil and filter, after cooling. The solution will contain zinc in the form of sodium zincate. Pass sulphuretted hydrogen through the solution when the zinc will be precipitated as a white substance.

The precipitate resulting from the sodium

hydrate test contains the manganese, nickel and cobalt. This is washed to remove the soluble zinc and is then dissolved in a small portion of warm hydrochloric acid. Add ammonium hydrate, sparingly, and ammonium acetate liberally. Sulphuretted hydrogen is then passed through the solution until precipitation is complete. This precipitate, containing nickel and cobalt, and the solution, the manganese.

Precipitate the manganese by adding sodium carbonate, then filter. Wash thoroughly and dissolve in hydrochloric acid. Ammonium hydrate, potassium hydrate or sodium hydrate will give a white precipitate.

The nickel and cobalt precipitate should be dissolved on a small portion of aqua regia and boiled to expel excess acid. Add a small amount of sodium carbonate and a solution of potassium cyanide until the precipitates in the solution are dissolved, then add a liberal portion of sodium hydrate and some bromine solution and filter. The solution contains the cobalt which may be confirmed by the blowpipe test for cobalt. The precipitate consists of the black sesquioxide of nickel. Confirm by the borax bead blowpipe test.

GROUP IV.

Group IV consists of three metals, barium, calcium and strontium.

The solution from which the minerals of Groups I, II, III, have been precipitated is made alkaline by the addition of ammonium hydrate. To this add ammoniac chloride to hold magnesium in solution and then add, little by little, ammonium carbonate until precipitation is complete. Do not boil. Filter. The filtrate contains the minerals of Group V. The precipitate holds the minerals of Group IV. The filtrate should be set aside for testing for the minerals of Group V.

The precipitate will contain, if such be in the ore, barium carbonate, calcium carbonate, strontium carbonate.

Wash the precipitate in a very little warm water and add acetic acid. To this add potassium chromate, gently warm and filter. The precipitate consists of barium chromate, distinguished by its color, yellow.

The filtrate holds calcium acetate and strontium acetate. Add a strong solution of ammonium sulphate and boil, then filter. The precipitate consists of strontium sulphate. Prove

by the flame test. The solution holds the calcium sulphate. Add ammonium oxalate and oxalic acid. A white precipitate proves the presence of calcium.

GROUP V.

Group V consists of Ammonium, Sodium, Potassium, Magnesium, Lithium, Rubidium, Caesium. The three last are rare metals, seldom met with, and will not here be considered.

Divide the filtrate set aside for testing the minerals of this group into three parts. To the first portion add sodium hydrate and heat in a glass test tube. Ammonium will pass off in a vapor and may be detected by the smell.

To the second portion add ammonium chloride, ammonium hydrate and hydrated sodium phosphate. Magnesium will be precipitated in white crystals.

Evaporate the third portion in a porcelain dish to dryness. If the first test showed ammonium this must be removed by heating the residue in a platinum dish until ammonia fumes are no longer detected. Then dissolve the residue in a small amount of water and add a drop of hydrochloric acid. Now dip a clean platinum wire, looped at the end, in the solu-

tion and heat in the Bunsen flame. A bright yellow color proves the presence of sodium. A lilac color confirms the presence of potassium. Add a little platinic chloride and stir. Potassium will fall as a yellow precipitate.

CHAPTER IV.

THE ORES AND CHEMICAL TESTS FOR THE SAME

A mineral may form combinations with several other minerals resulting in a variety of ores of the mineral. In this chapter the various ores are briefly described and chemical tests for the characterizing mineral in the ore are given. The ores are arranged alphabetically for greater convenience, instead of in the groups under which they usually are classified.

ALUMINUM

CRYOLITE (Aluminum - Sodium fluoride)
Consists of Aluminum 13., sodium 32.8, fluorine 54.2. Usually massive; white; translucent; sp. gr. 2.9 to 3.1. Fusible in the flame of a candle.

ALUNOGEN. Sulphur trioxide 36., alumina 15.4, water 48.6. Sp. gr. 1.6 to 1.8; hardness 1.5 to 2; white.

ALUNITE. Sulphur trioxide 38.5, alumina 37.1, potash 11.4, water 13. White, grayish or reddish. Sp. gr. 2.58 to 2.75, hardness 4.

Ambligonite. A lithium-aluminum phosphate, pale green to white; sp. gr. 3 to 3.11; hardness 6.

TESTS. Pulverize the ore. Mix a small portion of the powder with three times as much sodium carbonate and fuse with the blowpipe on a charcoal stick or in the porcelain cup. Dissolve the melt in hot water and make acid with hydrochloric acid. Boil to dryness and add 10 c.c. of hydrochloric acid, heat and add 250 c.c. water and again heat to boiling. Add a small quantity of ammonium hydrate and, if aluminum is present, it will be thrown down as a white, translucent precipitate, readily soluble in mineral acids and acetic acid.

AMMONIUM

SALMIK. Chlorine 66.3, ammonium 33.7. In white crusts, often yellowish or gray; translucent to opaque; pungent, salty taste; soluble in water.

MASCAGNITE. Sulphur trioxide 53.3, ammonium 22.8, water 23.9; yellow or yellowish gray; soluble in water.

TESTS. Powder the ore and dissolve in water. Boil the solution until about one-half has evaporated. Add a solution of sodium hydroxide and heat. The ammonium is expelled as a

vapor and may be detected by the smell.

2. Into the concentrated solution introduce a strip of turmeric paper. Ammonium will turn the yellow paper brown.

3. Put into the concentrated solution a small quantity of hydrogen platinum chloride. Ammonium will be precipitated as a yellow crystalline compound of ammonium platinic chloride. Heat strongly and the ammonium is expelled leaving a spongy residuum of platinum only.

ANTIMONY

NATIVE ANTIMONY. Sometimes combined with silver or arsenic or both. Color tin white; luster shining; streak white; sectile to brittle; sp. gr. 6.6 to 6.75; hardness 3 to 3.5; cleavage basal.

STIBNITE. Antimony 71.8, sulphur 28.2; lead-gray; luster shining; streak lead-gray to grayish black; sp. gr. 4.5 to 4.62; hardness 2; fr. uneven.

VALENTINITE. Antimony 83.56, oxygen 16.14; white, gray or reddish; luster pearly; streak white or gray; sp. gr. 5.57; hardness 2.5 to 3. fr. fibrous; sectile.

LIVINGSTONITE. Same as Stibnite, ex-

cept that it carries one and one-fourth per cent mercury.

TESTS. Powder the ore and place a small portion in the porcelain dish. Add 15 c.c. hydrochloric acid and boil to dryness. Add 20 c.c. water and and heat. Pour off a portion of this liquid into a clean porcelain dish and put in a piece of clean platinum wire and a small piece metallic zinc. Hydrogen will be evolved and if antimony is present it will stain the platinum wire brown or black. Pour on the wire a little nitric acid, warm, and the stain will disappear. Add a little ammonium sulphide and the antimony will fall as an orange-colored precipitate.

2. Dissolve some of the finely powdered ore in hydrochloric acid. Add to the solution a liberal amount of hydrogen peroxide and antimony is thrown down as a white precipitate, readily dissolved in tartaric acid.

3. To a solution prepared as above add ammonium sulphide. Antimony will be thrown down as a red or orange-red precipitate, soluble in caustic alkalies.

ARSENIC

NATIVE ARSENIC. Color and streak tin-

white; sp. gr. 5.65 to 5.95; hardness 3.5.

Orpiment. (Yellow arsenic sulphide.) Color and streak yellow; sp. gr. 3.4 to 3.5; hardness 1.5 to 2; cleavage perfect in one direction; luster pearly.

ARSENOLITE. (White arsenic.) Color white; sp. gr. 3.7; hardness 1.5; consists of arsenic 75.8, oxygen 24.2.

TESTS. Dissolve powdered ore in hydrochloric acid.

1. Sulphuretted hydrogen precipitates yellow arsenic sulphide, soluble in alkalies.

2. Silver nitrate precipitates a yellow or reddish brown powder, soluble in ammonia or dilute acid.

3. Copper sulphate gives a yellowish-green precipitate, soluble in ammonium hydrate or ammoniac chloride.

4. Magnesium sulphate gives a white, crystalline precipitate of ammonium-magnesium arsenate, insoluble in water.

BARIUM

BARITE. (Barium sulphate.) White, sometimes tinged with yellow, red, brown, blue or dark brown; sp. gr. 4.3 to 4.7; hardness 2.5 to

3.5; luster vitreous to pearly; sulphur trioxide 34.3, baryta 65.7.

WITHERITE. (Barium carbonate.) Carbon dioxide 22.3, baryta 77.7; yellowish or grayish white; sometimes in white crystals; specific gravity 4.29 to 4.35; hardness 3.4.

TESTS. Dissolve in hydrochloric acid.

1. Sulphuric acid precipitates white barium sulphate, insoluble in water or acids.

2. Ammonium carbonate precipitates barium carbonate as a white amorphous powder, insoluble in water but soluble in dilute acids.

3. Sulphuretted hydrogen gives a white, granular precipitate of barium chromate, insoluble in water or acetic acid; soluble in nitric or hydrochloric acids.

5. Hydrofluosilicic acid gives a white, crystalline precipitate of barium silicofluoride, partly soluble in water; insoluble in alcohol.

BISMUTH

NATIVE BISMUTH. Color and streak white, slightly tinged with red; sp. gr. 9.7 to 9.8; hardness 2 to 2.5; brittle; usually massive, sometimes granular; cleavage rhombohedral, even.

TETRADYMITÉ. (Bismuth telluride) Steel-gray; sp. gr. 7.2 to 7.9; hardness 1-5 to 2. Consists of bismuth 51.9, tellurium 48.1.

BISMUTHINE. Lead-gray; bismuth 81, sulphur 19.

BISMUTITE. (Bismuth oxide). White; bismuth 88, carbonic oxide and water 12.

TESTS. Dissolve the powdered ore in equal parts of hydrochloric and nitric acids. Boil nearly to dryness and add water equal in bulk to the acid solution. Filter. Put a little of the solution in a test tube then nearly fill the tube with water. Bismuth will fall as a white precipitate.

2. To the acid solution add potassium hydrate. White bismuth powder will be precipitated.

3. Sulphuretted hydrogen gives a dark brown or nearly black precipitate of bismuth sulphide.

CADMIUM

GREENICKITE. Light yellow; lustrous, nearly transparent; sp. gr. 4.5 to 5; hardness 3 to 3.5; hexagonal prisms.

EGGONITE. Light grayish brown, trans-

lucent orthorhombic prisms; sp. gr. 4.5 to 5; hardness 4 to 5.

TESTS. Dissolve ore in nitric acid in a porcelain dish. Boil until acid is half gone. Add equal volume sulphuric acid and boil until dense white fumes are evolved. Add three times as much water and boil several minutes. Add five or six times as much water and treat with sulphuretted hydrogen. A yellow precipitate indicates cadmium, which is insoluble in potassium cyanide.

2. Potassium hydrate precipitates cadmium as a white powder, soluble in ammonium hydrate.

CALCIUM

FLUORITE. (Fluor Spar—Calcium Fluoride). White, light green, purple or clear yellow, rarely rose-red and sky blue; transparent or translucent; brittle; sp. gr. 3 to 3.25; hardness 4; consists of fluorine 48.7, calcium 51.3.

GYPSUM. (Hydrous calcium sulphate). White, gray, yellowish, reddish, brownish, rarely black; brittle; sulphur trioxide 46.5, lime 32.6, water 20.9; sp. gr. 2.33; hardness 1.5 to 2; transparent to opaque.

ANHYDRITE. (Anhydrous Calcium Sulphate). White, or tinted with gray, red or blue; transparent or nearly so; luster pearly; sulphur trioxide 58.8, lime 41.2; sp. gr. 2.95 to 2.97; hardness 3 to 3.5.

ULEXITE. (Calcium-Sodium-Borate). White to gray; luster silky; sp. gr. 1.65; hardness 1. Borax of commerce.

Scheelite. (Calcium Tungstate). See tungsten ores.

APATITE. (Calcium Phosphate). Greenish, yellowish green, bluish green, grayish green, rarely yellow, blue, reddish-brown, colorless; transparent to opaque; phosphorus pentoxide 40.92, lime 53.80, chlorine 6.82; sp. gr. 3.18 to 3.25; hardness 5.

CALCITE. (Calcium Carbonate). Topaz-yellow, green, brown or black; nearly transparent; brittle; sp. gr. 2.8 to 2.9; hardness 3.5 to 4; calcium carbonate 54.35, magnesium carbonate 45.65.

TESTS. Calcium compounds are partially soluble in cold water. Dissolve ore in hydrochloric acid.

1. Sodium carbonate precipitates calcium carbonate.

2. Sulphuric acid precipitates calcium sulphate, soluble in ammonium sulphate.

3. Oxalic acid gives a white crystalline precipitate of calcium oxalate, insoluble in ammonium hydrate.

CERIUM

YTTROCERITE. Color, violet, blue, or reddish-brown; luster glistening, opaque; fluorine 25.1; lime 47.6; cerium protoxide 18.2, yttria 9.1; sp. gr. 3.4 to 3.5; hardness 4 to 5.

SAMARSITE. Velvet-black; luster shining; streak dark, reddish-brown; opaque; sp. gr. 5.6 to 5.8; hardness 5.5 to 6.

MONAZITE. Brown or reddish-brown; nearly opaque; brittle; sp. gr. 4.8 to 5.1; hardness 5.

TESTS. See test under Group III.

CHROMIUM

CHROMITE. Iron-black or brownish-black; massive; sub-metallic; streak dark brown; iron protoxide 32, chromium sesquioxide 68; sp. gr. 4.32 to 4.6; hardness 5.5.

TESTS. Fuse a small portion of the powdered ore in a porcelain dish with four times the quantity of sodium peroxide. Dissolve in hot

water and filter. If chromium is present the solution will be yellow. Make the solution acid with acetic acid and add a few drops of lead acetate and chromium will be deposited in yellow crystals, soluble in sodium hydrate.

COBALT

LINNAEITE. (Cobalt-Sulphide). Sulphur 42, cobalt 58; pale steel-gray, tarnishing copper-red; streak blackish gray; sp. gr. 4.8 to 5; hardness 5.5.

SMALTITE. (Cobalt Glance). Tin-white to steel-gray; streak grayish-black; brittle; fracture uneven; sp. gr. 6.4 to 6.9, hardness 5.5 to 6.

COBALTITE. Arsenic 45.2, sulphur 19.3, cobalt 35.5; silver-white tinged with red, sometimes steel-gray; streak grayish-black; brittle sp. gr. 6 to 6.3; hardness 5.5.

ASBOLITE. (Cobalt Oxide). Earthy; massive; black; dissolves in hydrochloric acid.

ERYTHRITE. (Cobalt Bloom). Peach-red or crimson-red, sometimes grayish or greenish; arsenic 38.4, cobalt 37.6, water 24.

TESTS. Dissolve powdered ore in nitric acid, boil to dryness, dilute with water, filter, add

tartaric acid and excess of ammonia and a few drops of ferricyanide. A deep red color indicates cobalt.

COPPER

The ores of copper are many. Many rocks carry copper sufficiently to stain them and give the copper reactions which do not carry sufficient metal to warrant production. The principal commercial ores are here described:

NATIVE COPPER. Color copper-red; ductile and malleable; sp. gr. 8.8 to 8.95; hardness 2.5 to 3.

TEST FOR NATIVE COPPER. Dissolve in nitric acid and add ammonia. A deep azure-blue color results.

CHALCOCITE. (Copper Glance). Sulphur 20.2, copper 79.8; color and streak blackish-gray, often tarnished blue or green; sp. gr. 5.5 to 5.8; hardness 2.5 to 3.

CHALCOPYRITE. (Copper Pyrites). Sulphur 34.9, copper 34.6, iron 30.5; color brass yellow, frequently deep yellow and iridescent—disintegrated “peacock”; streak greenish-black; sp. gr. 4.15 to 4.3; hardness 3.5 to 4.

BORNITE. (Variegated Copper Pyrites).

Sulphur 28.6, copper 55.58, iron 16.36; color pale, reddish-yellow, tarnishing to blue and reddish; sp. gr. 4.4 to 5.5; hardness 3.

TETRAHEDRITE. (Gray Copper). Composition varies; usually sulphur, copper antimony; sometimes contains arsenic, iron, zinc, silver; color steel-gray to blackish; streak steel-gray to brown and red; sp. gr. 4.7 to 5; hardness 3 to 4.5.

ATACAMITE. (Copper Oxichloride). Chlorine 16.64, oxygen 11.25; copper 11.25, water 12.66; color green; streak apple-green; sp. gr. 3.76 to 3.9; hardness 3 to 3.5.

MALACHITE. (Green Copper Carbonate). Carbon dioxide 19.9, copper oxide 71.9, water 8.2; color light green; streak pale green; sp. gr. 3.7 to 4; hardness 3.5 to 4.

AZURITE. (Blue Copper Carbonate). Carbon dioxide 25.6, copper oxide 69.2, water 5.2; color azure-blue; streak bluish; sp. gr. 3.5 to 3.33; hardness 3.5 to 4.5.

DIOPTASE. (Copper Silicate). Silica 38.1, copper oxide 50.4, water 11.5; color emerald-green; sp. gr. 3.28 to 3.33; hardness 5.

CHRYSOCOLLA. (Hydrous Copper Silicate). Silica 34.2, copper oxide 45.3, water 20.5;

color bluish-green; sp. gr. 2 to 2.4; hardness 2 to 4.

TESTS. Dissolve the powdered ore in nitric acid by boiling. Dilute with water. Add ammonium hydrate. A deep blue color signifies copper.

2. To a solution prepared as above add potassium hydrate in liberal quantity. Copper will be precipitated as a blue deposit. Boil and the precipitate changes to black.

3. In a dilute nitric solution put a piece of bright iron or zinc and metallic copper is precipitated.

4. To a dilute nitric solution add a considerable quantity of ammonium hydroxide. A blue color signifies copper. Add iron or zinc and the copper will appear as a deposit on the iron or zinc.

GOLD

Gold is found in so many rocks and in connection with so many other minerals that it is impossible to attempt to describe or classify them. It mostly occurs native, but is alloyed with a number of other minerals, chiefly with silver, iron and tellurium. Native it is yellow

of varying shades. It is ductile and malleable; has a specific gravity of, when pure, 19 to 19.3, and a hardness of 2.5 to 3. When not alloyed it is known as "free gold" and no other test is needed than the mortar and pan. When the pan yields yellow particles of metal and there is a doubt in the prospector's mind regarding its identity, a few drops of nitric acid on the metal will quickly settle the matter. If the yellow particles are unaffected by the acid it is gold.

TESTS. When the gold is alloyed with other metals it requires treatment to release the gold and determine its presence. A simple test is to dissolve the powdered ore in aqua regia, boil nearly to dryness, dilute with warmed water, and drop in a few drops of stannous chloride. If the solution turns purple gold is present.

IRON

NATIVE IRON, Generally massive, with octahedral cleavage; color and streak iron-gray; ductile and malleable; sp. gr. 7.3 to 7.8; hardness 4.5; is altered by the magnet, a reliable test.

PYRITE. (Iron Desulphide). Usually in cubes,

also massive; color brass yellow; streak brownish-black; brittle; sp. gr. 4.8 to 5.2; hardness 6 to 6.5; sulphur 53.3, iron 46.7.

PYRRHOTITE. (Iron Sulphide). Magnetic; in hexagonal prisms and massive; color bronze-yellow to copper-red; streak dark grayish-black; brittle; sp. gr. 4.5 to 4.65; sulphur 39.5, iron 60.5; often contains 2 or 3 per cent nickel.

ARSENOPYRITE OR MISPICKEL. (Arsenical Pyrite). In rhombic prisms and massive; silver-white; streak dark, grayish-black; sp. gr. 5.67 to 6.3; hardness 5.5 to 6; arsenic 46, sulphur 19.6, iron 34.4; sometimes contains 4 or 5 per cent cobalt, displacing a part of the iron.

HEMATITE. (Iron Sesquioxide). Dark steel-gray or iron-black; streak reddish-brown or cherry-red; sp. gr. 4.5 to 5.3; hardness 5.5 to 6.5.

MENACCANITE. Iron-black; streak sub-metallic; sp. gr. 4.5 to 5; hardness 5 to 6.

MAGNETITE. (Magnetic Iron). Iron-black, streak black; brittle; sp. gr. 5 to 5.1; hardness 5.5 to 6.5; oxygen 27.6, iron 72.4.

FRANKLINITE. Iron-black or reddish; streak dark reddish-brown; brittle; sp. gr. 4.5 to 5.1; hardness 5.5 to 6.5; composition, iron, zinc, magnesium.

CHROMITE. (Chromic Iron). Iron-black or brownish-black; streak dark-brown; sp. gr. 4.32 to 4.6; hardness 5.5; iron protoxide 32, chromium sesquioxide 68; these constituents are often partially displaced by aluminum and manganese.

LIMONITE. (Brown Hematite). Dark-brown or black to ocher-yellow; streak yellowish or yellow-brown; sp. gr. 3.6 to 4; hardness 5 to 5.5; iron sesquioxide 85.6, water 14.4.

MELANTERITE. (Iron Vitriol). Greenish to white; brittle; sp. gr. 1.83; hardness 2; sulphur trioxide 28.8, iron protoxide 25.9, water 45.3.

COLUMBITE. Iron-black to brownish-black; streak reddish-brown; brittle; sp. gr. 5.4 to 6.5; hardness 5 to 6; niobium pentoxide 79.6, iron protoxide 16.4, magnesia protoxide 4.4, tin oxide 0.5, lead and copper oxides 0.1.

VIVIANITE. (Hydrous Iron Phosphate). Deep blue, green or white; streak bluish; sp. gr. 2.58 to 2.68; hardness 1.5 to 2; phosphorus pentoxide 28.3, iron protoxide 43, water 28.7.

SIDERITE. (Iron Carbonate). Grayish-white to brown, or brownish-red; streak uncolored; sp. gr. 3.7 to 3.9; hardness 3 to 4.5; carbon dioxide 37.9, iron protoxide 62.1.

TESTS. Dissolve the powdered ore in equal parts of nitric and hydrochloric acids. Boil away one-half. Dilute with six times the amount of water and filter. Add liberal quantity of ammonium hydroxide and iron will come down as a reddish-brown precipitate. Dissolve the precipitate in dilute hydrochloric acid and add a few drops of potassium sulphocyanide. If iron is present the solution will become blood-red.

2. Pass sulphuretted hydrogen through a solution prepared as in the foregoing test. Add potassium ferrocyanide. A dark blue precipitate indicates iron.

3. Sodium hydrate, ammonium hydrate or potassium hydrate will give a brown precipitate of iron.

IRIDIUM

IRIDIOSMINE. A compound of iridium and osmium; sp. gr. 19.5 to 21.1; hardness 6.7.

TEST. Iridium is not soluble in any of the acids or in aqua regia. Heat with a fused mixture of sodium nitrate and hydroxide in a silver vessel. Treat the residue with aqua regia. The solution. The dark color will disappear and a red. Pass sulphuretted hydrogen through the

solution. The dark color will disappear and a dark-brown precipitate of trisulphate of iridium will result.

LEAD

NATIVE LEAD. Native lead is exceedingly rare. Occurs in thin sheets or in globules. Sp. gr. 11.35.

GALENA. (Lead Sulphate). Color and streak lead-gray; luster shining; sulphur 13.4, lead 86.6.

MINIUM. (Oxide of Lead). Bright red mixed with yellow; sp. gr. 4.6.

ANGLESITE. (Lead Sulphate). White or slightly gray—sometimes green; sp. gr. 6.35 to 6.4; hardness 2.75 to 3.

CROCOSITE. (Lead Chromate). Red; streak orange-yellow; sp. gr. 5.9 to 6.1; hardness 2.5 to 3; Chromium trioxide 31.1, lead 68.9.

PYROMORPHITE. (Lead Phosphate). Green to brown, or orange; streak white; sp. gr. 6.8 to 7.1; hardness 3.5 to 4; phosphorus pentoxide 15.71, lead oxide 82.27, chlorine 2.62.

CERUSSITE. (Lead Carbonate). Whitish or grayish; sp. gr. 6.46 to 6.48; hardness 3 to 3.5; carbon dioxide 16.5, lead oxide 83.5.

TESTS. Dissolve the powdered ore in nitric acid. Dilute and filter. Metallic zinc will precipitate crystals of lead.

2. Sulphuric acid will precipitate white lead sulphate, soluble in nitric acid.

3. Sulphuretted hydrogen will precipitate black lead sulphate, soluble in nitric acid.

MANGANESE

MANGANOSITE. (Manganese Protoxide). Emerald-green, freshly broken, brown after exposure; sp. gr. 5.18 to 5.6.

PYROLUSITE. (Manganese Dioxide). Iron-black; streak black; sp. gr. 4.8; hardness 2 to 2.5; manganese 63.2, oxygen 36.8.

PSILOMELANE. Black or greenish; streak reddish or brownish-black; shining; sp. gr. 4 to 4.4; hardness 5 to 6.

WAD. (Bog Manganese). Massive and earthy; color and streak black; sp. gr. 3 to 4; hardness 1 to 6.

MALLARDITE. (Manganese Sulphate). White, sometimes fibrous.

TRIPHYLITE. (Hydrous Phosphate). Greenish or bluish gray or brownish-black; streak grayish white; sp. gr. 3.54 to 3.6; hardness 5.

TRIPLITE. Blackish-brown; streak yellowish gray; sp. gr. 3.4 to 3.8; hardness 5 to 5.5; about 30 per cent manganese.

RHODOCHROSITE. Rose-red; sp. gr. 3.4 to 3.7; hardness 3.5 to 4.5; carbonic acid 38.6, manganese protoxide 61.4.

TESTS. Mix powdered ore with equal parts potassium nitrate and sodium carbonate and fuse. If manganese is present the substance will become a bright green, hot, bluish green cold. Dissolve in water and if manganese is present the solution will be purplish-red.

2. Boil powdered ore in nitric acid and add peroxide of lead. A reddish-violet color indicates manganese.

MAGNESIUM

PERICLASITE. (Magnesium Oxide). Grayish to dark green; occurs in small crystals; sp. gr. 3.674; hardness 5.95.

BRUCITE. (Magnesium Hydrate). White, grayish or greenish; sp. gr. 2.55 to 2.45; hardness 2.5; magnesia 69, water 31; resembles talc or gypsum; soluble in acids.

EPSOMITE. (Magnesium Sulphite). White; soluble; bitter; the epsom salts of commerce; sulphur trioxide 32.5, magnesia 16.3, water 51.2.

BORACITE. (Magnesium Boreat). White, grayish, yellowish or greenish; sp. gr. 2.97; hardness of crystals 7; Boron trioxide 62. Magnesia 31, chlorine 7.

MAGNESITE. (Magnesium Carbonate). White, grayish white, yellowish or brown; sp. gr. 3 to 3.2; hardness 3 to 4.5; carbon dioxide 52.4, magnesium 47.6.

TESTS. Fuse pulverized ore with sodium carbonate. Dissolve in water and make acid with hydrochloric acid. Evaporate to complete dryness, cool and add 5 c. c. of hydrochloric acid. Heat and add 60 c. c. water, boil again and filter. Again heat and add 10 c. c. ammonium chloride and sufficient ammonia to make alkaline. Filter to remove any precipitate and add 10 c. c. sodium and ammonium phosphate and 25 c. c. ammonia. Stir mixture thoroughly. Magnesium will be shown by a white precipitate.

MERCURY

NATIVE MERCURY. Is found in fluid globules disseminated through the gangue. Its color is tin-white or silver-white; sp. gr., when pure, 13.58.

CINNABAR. Bright red to brownish-red and black; streak scarlet; sp. gr. 9; hardness 2 to 2.5; sulphur 13.8, mercury 86.2.

TESTS. Nitric acid dissolves mercury. In diluted solution suspend a piece of clean, bright metallic copper. Metallic mercury will be deposited on the copper.

2. Add to a mercurous solution tin bichloride. At first a white precipitate of mercuric chloride results, followed by a gray precipitate of mercury.

MOLYBDENUM

MOLYBDENITE. Lead-gray color and streak; occurs in hexagonal plates and masses; sp. gr. 4.45 to 4.8; hardness 1 to 1.5; sulphur 41, molybdenum 59.

WULFENITE. Yellow; resinous; contains molybdenum trioxide 34.25, lead protoxide 64.42.

TEST. Dissolve powdered ore in nitric acid and boil to complete dryness. Cool and add 3 c. c sulphuric acid. Boil to nearly dryness. Again cool and add a few drops of alcohol. If molybdenum is present the solution will be colored a vivid blue.

NICKEL

Nickel and cobalt are closely associated and the ores are often mixed. Some of the ores listed under cobalt are liable to carry nickel. In addition to those may be described:

MILLERITE. (Nickel Sulphide). One of the most valuable of the nickel ores. Color brass-yellow or bronze-yellow; brittle; streak bright; sp. gr. 3.65; hardness 3 to 3.5; sulphur 35.6, nickel 64.4.

NICCOLITE. (Arsenical Nickel). Pale copper-red; streak brownish-red; luster metallic; sp. gr. 7.35 to 7.67; hardness 5 to 5.5; nickel 44, arsenic 56; arsenic sometimes partially displaced by antimony.

BREITHANPTITE. (Antimonical nickel). Pale copper-red or violet; sp. gr. 7.54; hardness 5.5 to 6; antimony 67.8, nickel 32.2.

GERSDORFFITE. (Nickel Glance). Yellowish-white to steel-gray; sp. gr. 5.6 to 6.0; hardness 5.5; arsenic 45.5, sulphur 19.4, nickel 35.1.

MELONITE. (Nickel Telluride). Reddish-white. Composition varies.

TESTS. Dissolve powdered ore in aqua regia. Boil to dryness and dissolve residue in water. Warm and filter. Add ammonium hydrate. If nickel is present in the solution it will turn blue.

2. Cyanide of potassium added to a solution prepared as above gives a pale-green precipitate soluble in excess of the reagent.

PLATINUM

NATIVE PLATINUM. Color and streak tin-white to pale or dark steel gray; luster metallic, shining; ductile and malleable; sp. gr. 16 to 19 if combined with other metals, if pure 21.15; hardness 4 to 4.5; usually combined with iridium, palladium, osmium, rhodium, sometimes with iron or copper.

TEST. Dissolve finely powdered ore in aqua regia, boil to complete dryness and let heat after dry to dispel all traces of acids. Let cool, add 2 fluid ounces water, heat, stirring mixture well. Filter. Add to the filtrate a few drops of iodide of potassium. If platinum is present the solution will turn a rose-red color.

POTASSIUM

SYLVITE. White or colorless; salty taste;

sp. gr. 1.9 to 2; hardness 2; chlorine 47.5, potassium 52.5.

NITER. (Potassium Nitrate). In thin white crusts; salty taste; sp. gr. 1.97; hardness 2; nitrogen pentoxide 53.4, potash 46.6.

TEST. Dissolve in water. Add hydrochloric acid. Potassium chloride is precipitated in yellow crystals. Evaporate to dryness and add alcohol. The precipitate, if potassium, is not dissolved.

SILVER

NATIVE SILVER. Color and streak silver-white and shining; surface metal will be tarnished black; sectile, malleable; sp. gr. 10.1 to 11.1.

ARGENTITE. (Silver Glance). Color and streak dark lead-gray, streak shining; luster metallic; sp. gr. 71.19 to 7.4; hardness to 2.5, sulphur 12.9, silver 87.1.

PYRRARGYRITE. (Ruby Silver). Black to dark-red; streak red; luster shining, metallic; sp. gr. 5.7 to 5.9; hardness 2 to 2.5; sulphur 17.7, antimony 22.5, silver 59.8.

STEPHANITE. Color and streak iron-black; sp. gr. 6.27; hardness 2 to 2.5; sulphur

16.2, antimony 15.3, silver 68.5.

CERARGYRITE. (Horn Silver). Gray, green or blue; resemble horn or wax; luster resinous; sp. gr. 5.3 to 5.5; hardness 2 to 2.5; chlorine 24.7, silver 75.3.

TESTS. Dissolve powdered ore in nitric acid. Dilute and filter. Hydrochloric acid precipitates white silver chloride, insoluble in nitric acid; soluble in ammonium hydrate.

2. Potassium iodide precipitates yellow silver oxide, insoluble in ammonium hydrate.

3. Copper precipitates metallic silver.

SODIUM

HALITE. (Sodium Chloride). White, grayish, rose-red, yellow, or amethystine; sp. gr. 2.165; hardness 2; chlorine 60.7, sodium 39.3.

MIRABILITE. (Hydrous Sodium Sulphate) White or yellowish-white crusts; sulphur trioxide 24.8, soda 19.3, water 55.9.

BORAX. (Hydrous Sodium Biborate). Crystals white or colorless and transparent; sp. gr. 1.716; hardness 2 to 2.5; boron trioxide 36.6, soda 16.2, water 47.2.

NITRATINE. (Sodium Nitrate). White,

grayish or brownish; nitrogen pentoxide 63.5, soda 36.5.

NATRON. (Hydrous Sodium Carbonate). In white, yellowish or grayish crusts; carbon dioxide 26.7, soda 18.8, water 54.5; effervesces in acids.

TESTS. Dissolve in warm water. Add potassium-tin oxide and precipitate white sodium tin oxide.

2. Dissolve in hydrochloric acid and add platanic chloride. The precipitate will be red crystals of sodium-platinic chloride.

STRONTIUM

CELESTITE. (Strontium Sulphate). White, bluish, or reddish; brittle; transparent to translucent; sp. gr. 3.9 to 4; hardness 3 to 3.5; sulphur trioxide 43.6, strontia 56.4.

STRONTIANITE. (Strontium Carbonate). Pale greenish-white or white, gray and yellowish-brown; luster vitreous or resinous; transparent to translucent; sp. gr. 3.6 to 3.73; hardness 3.5 to 4; carbon dioxide 29.7, strontia 70.3; effervesces in cold dilute acids.

TESTS. Sodium hydrate, ammonium hydrate, ammonium carbonate or sodium carbonate

give white precipitate, soluble in acids.

2. Sulphuric acid gives a precipitate of strontium sulphate.

TANTALUM

COLUMBITE. Iron-black or brownish-black; streak dark brown or reddish; luster sub-metallic, shining; brittle; sp. gr. 5.4 to 6.85; hardness 5 to 6.

TANTALITE. Similar to above. Both contain variable proportions of tantalum, niobium, manganese, iron and impurities.

TEST. Mix powdered ore with acid potassium sulphate and fuse in a porcelain dish. Cool and pulverize the mass. Boil in water. Settle and filter. Treat filtrate with hydrofluoric acid in a platinum dish, filter, and to the filtrate add sulphuric acid. Evaporate to dryness and heat after dry to dispel all acid. Dissolve residue in hydrofluoric acid and boil to concentration. If tantalum is present it will be precipitated in needle-like crystals.

TELLURIUM

NATIVE TELLURIUM. Color and streak tin-white; usually granular massive; brittle; sp. gr. 6.1 to 6.3; hardness 2 to 2.5.

TETRADYMITÉ. (Bismuth Telluride). Pale steel-gray; luster splendid metallic; sp. gr. 7.2 to 7.9; hardness 1.5 to 2; contains bismuth, tellurium and sometimes sulphur and selenium.

CALVERITE. Bronze-yellow; gold telluride; tellurium 55.5, gold 44.5, sp. gr. 9.043.

NAGYAGITE. Lead Tellurium). Foliated like graphite; color and streak blackish lead-gray; sp. gr. 7.085; hardness 1 to 1.5; tellurium 32.2, lead 54, gold 9.

COLORADORITE. Grayish-black mercury telluride; sp. gr. 8.627.

HESSITE. Silver Telluride). Lead-gray to steel-gray; sp. gr. 8.3 to 8.6; tellurium 37.2, silver 62.8.

SYLVANITE. Color and streak silver-white, steel-gray or brass-yellow; sp. gr. 7.9 to 8.33; hardness 1.5 to 2; tellurium 55.8, gold 28.5, silver 15.7.

MELONITE. (Nickel Tellurium). Reddish-white ore.

TESTS. Dissolve powdered ore in hydrochloric acid. Sulphuretted hydrogen deposits brown tellurium sulphide.

2. Boil with nitric acid and a violet solution results.

TIN

Tin forms a minor constituent in a number of ores including tungsten, uranium, niobium, tantalum, etc. The commercial ores are:

STANNITE. Color steel-gray to iron-black; streak blackish; brittle; sp. gr. 4.3 to 4.6; hardness 4; sulphur 30, tin 27, copper 30, iron 13.

CASSITERITE. (Tin Oxide). Brown, black, or yellow; streak light gray or brown; sp. gr. 6.4 to 7.02; hardness 6 to 7; oxygen 21.33, tin 78.67.

TESTS. From an acid solution of the tin ore sulphuretted hydrogen precipitates dark-brown tin sulphide, soluble in alkalies.

2. Zinc precipitates spongy tin.

Mercuric chloride precipitates white stannous mercurial chloride.

TITANIUM

Rutile. Reddish-brown to nearly red; streak light brown; transparent to opaque; luster sub-metallic; brittle; sp. gr. 4.18 to 4.25; hardness 6 to 6.5; oxygen 39, titanium 61.

OTHAEDRITE. Brown; sp. gr. 3.8 to 3.95; hardness 5.5 to 6.

TESTS. Fuse pulverized ore with soda and dissolve melt in hydrochloric acid. Ammonium hydrate gives a white precipitate of titanium hydrate.

2. Tin or zinc boiled in the acid solution gives a violet or blue color to the solution and eventually results in a precipitate, blue at first, turning white.

TUNGSTEN

SCHEELITE. (Lime Tungstate). White or creamy pale yellow, brownish, greenish, or reddish; sp. gr. 5.0 to 6.1; hardness 4.5 to 5; calcium 14, tungsten 64, oxygen 22.

WOLFRAMITE. (Manganese Tungstate). Dark grayish-black; luster submetallic, shining to dull; streak dark reddish-brown; sp. gr. 7 to 7.5; hardness 3 to 3.5; tungsten 51.25, manganese 15.32, iron 15.61, oxygen 17.82.

HUBNERITE. (Manganese Tungstate). Brown to brown-black; streak grayish-brown; brittle; luster resinous; sp. gr. 7.2; hardness 4; tungsten 60.7, manganese 18.3, oxygen 21.

FERBERITE. (Iron Tungstate). Similar to Wolframite, the manganese being replaced with iron.

TEST. Dissolve finely powdered ore by boiling in a glass tube with hydrochloric acid. For scheelite boil ten minutes. With the darker ores twice that length of time. Drop a piece of metallic zinc in the acid solution. A strong blue or violet-blue color is proof of tungsten. The solution in the case of hubnerite is apt to change to brown.

URANIUM

URANITE OR PITCHBLEND. (Uranium Oxide). Grayish, brownish or black; streak black; luster submetallic or dull; sp. gr. 9.2 to 9.3; hardness 5.5; composition variable.

TOBERNITE. Color green; streak pale green; sp. gr. 3.3 to 3.6; hardness 2 to 2.5; phosphorus pentoxide 15.1, uranium trioxide 61.2, copper oxide 8.4, water 16.3.

TESTS. Dissolve in aqua regia. Boil to dryness. Dissolve residue in hot water; Filter. Ammonium hydrate, potassium hydrate or sodium hydrate precipitates yellow uranic hydroxide.

2. Potassium ferrocyanide gives a reddish-brown precipitate.

VANADIUM

VANADINITE. Red, yellow or brown; streak pale yellow; brittle; fracture even; luster resinous; composition lead and vanadium; sp. gr. 6.9 to 7.23; hardness 1.5.

DESCLOIZITE. Black-brown to olive-green; luster resinous; brittle; fracture uneven; lead and vanadium; sp. gr. 6 to 6.1; hardness 1.5.

TESTS. Dissolve powdered ore in equal parts nitric and hydrochloric acids. Boil. Add one-half as much sulphuric acid and boil. Cool. Dilute with equal quantity water, boil and filter. Add to the solution two or three drops hydrogen peroxide. If vanadium is present the solution will turn a brownish-red color.

2. Dissolve ore in sulphuric acid and add zinc. The solution turns green, then blue, violet and lavender.

ZINC

SPHALERITE. (Zinc Sulphide). Wax-yellow, brownish-yellow, black, green, red and white; streak white to reddish-brown; brittle; luster resinous; sp. gr. 3.9 to 4.2; hardness 3.5 to 4; sulphur 33, zinc 67.

ZINCITE. (Zinc Oxide). Bright red or deep yellow; streak orange-yellow; luster brilliant, subadamantine; sp. gr. 5.68 to 5.74; hardness 4 to 4.5; oxygen 19.7, zinc 80.3.

GOSLARITE. (Zinc Sulphide). White; luster vitreous; brittle; sp. gr. 2.036; hardness 2 to 2.5; zinc oxide 28.2, sulphur trioxide 27.9, water 43.9.

WILLEMITE. (Zinc Silicate). Color whitish, greenish, yellow, apple green, flesh-red, yellowish-brown; streak uncolored; brittle; sp. gr. 3.89 to 4.18; hardness 5.5; silica 27.1, zinc oxide 72.9.

CALAMINE. (Hydrous Zinc Silicate). White to bluish, greenish or brownish; streak uncolored; luster vitreous; brittle; sp. gr. 3.16 to 3.49; hardness 4.5 to 5.

TESTS. Boil pulverized ore in nitric acid, add 5 grams potassium chlorate and boil to dryness. Cool. Add 15 c. c. ammonia, 10 c. c. water and 10 grams ammonium chloride. Heat and filter. Boil to dispel excess of ammonia, add 5 c. c. hydrochloric acid and treat with sulphuretted hydrogen. Filter. Make filtrate alkaline with ammonia. Zinc will fall as a white precipitate.

2. To an acid solution of ore add potassium ferrocyanide. A white precipitate denotes zinc.

CHAPTER V

SOLUBILITY OF MINERALS

BISMUTH—Native, Tetradymite, Bismuthine, Bismuthite.

Solvent Agent—Hydrochloric acid.

CADMIUM—Greenockite, Eggonite.

Solvent Agent—Nitric acid.

CALCIUM—Fluorite, Gypsum, Anhydrite, Ulexite, Apatite, Calcite, Aragonite, Dolomite.

Solvent Agent—Hydrochloric acid.

CERIUM—Yttrocerite, Samarskite, Monazite.

Solvent Agent—Aqua regia.

CHROMIUM—Chromite.

Fuse with sodium peroxide and dissolve in hot water.

COBALT—Linnaeite, Smaltite, Erythrite.

Solvent Agent—Nitric acid.

COPPER—Native, Chalcocite, Chalcopyrite, Bornite, Tetrahedrite, Atacamite, Cuprite, Malachite, Azurite, Dioptase, Chrysocolla.

Solvent Agent—Nitric acid.

GOLD—Native or Ores.

Solvent Agent—Aqua Regia.

IRON—Native, Pyrite, Pyrrhotite, Arsenopyrite, Hematite, Menaccanite, Magnetite, Franklinite, Chromite, Limonite, Melanterite, Columbite, Vivianite, Siderite.

Solvent Agent—Equal parts nitric and hydrochloric acids.

IRIDIUM—Iridosmine.

Fuse with mixture of sodium nitrate and hydroxide in silver vessel and dissolve in aqua regia.

LEAD—Native, Galena, Minium, Anglesite, Crococite, Pyromorphite, Cerussite.

Solvent Agent—Nitric acid.

MANGANESE—Manganosite, Pyrolisite, Psilomelane, Wad, Milliardite, Triphylite, Triplite, Rhodochrosite.

Fuse by mixing ore with equal parts sodium carbonate, dissolve melt in water or nitric acid.

Magnesium—Periclasite, Brucite, Epsomite, Boracite, Magnesite.

Fuse with sodium carbonate and dissolve in water.

Mercury—Native, Cinnabar.

Solvent Agent—Nitric acid.

MOLYBDENITE—Wulfenite, Molybdenite.

Solvent Agent—Nitric acid.

NICKEL—Millerite, Breithanptite, Gersdorffite,
Melonite.

Solvent Agent—Aqua regia.

PLATINUM—Native.

Solvent Agent—Aqua regia.

POTASSIUM—Sylvite, Niter.

Solvent Agent—Water.

SILVER—Native, Argentite, Pyragyrite, Stephanite, Cerargyrite.

Solvent Agent—Nitric acid.

SODIUM—Halite, Mirabilite, Borax, Nitraline,
Natron.

Solvent Agent—Warm water.

STRONTIUM—Celestite, Strontianite.

Solvent Agent—Dilute acids.

TANTALUM—Columbite, Tantalite.

Fuse with acid potassium sulphate and
dissolve in boiling water.

TELLURIUM—Native, Tetradyte, Calverite,
Coloradoite, Hessite, Sylvanite, Melonite.

Solvent Agent—Hydrochloric acid.

TIN—Stannite, Cassiterite.

Solvent Agent—Nitric acid.

TITANIUM—Rutile, Octahedrite.

Fuse with soda and dissolve in hydrochloric acid.

TUNGSTEN—Scheelite, Wolframite, Hubnerite, Ferberite.

Solvent Agent—Hydrochloric acid.

URANIUM—Uraninite, Tobernite.

Solvent Agent—Aqua regia.

VANADIUM—Vanadinite, Descloizite.

Solvent Agent—Equal parts nitric and hydrochloric acids.

ZINC—Sphalerite, Zincite, Goslarite, Willemite.

Solvent Agent—Nitric acid.

CHAPTER VI.

REAGENTS AND SYMBOLS

The operator will have occasion to resort to a number of reagents and it is sometimes important to know the symbol as some formulas and most works on chemical analysis, which he may have occasion to consult, use only the symbol. The following reagents and their symbols are therefore given for his convenience.

Reagent	Symbol
Acetic Acid	$\text{HC}_2\text{H}_3\text{O}_2$
Alcohol	$\text{C}_2\text{H}_5\text{OH}$
Ammonium Carbonate	$(\text{NH}_4)_2\text{CO}_3$
Ammonium Chloride	NH_4Cl
Ammonium Molybdate	$(\text{NH}_4)_2\text{MoO}_4$
Ammonium Oxalate	$(\text{NH}_4)_2\text{C}_2\text{O}_4$
Ammonium Sulphide	$(\text{NH}_4)_2\text{S}$
Ammonium Sulphohydrate	NH_4HS
Ammonium Sulphocyanide	NH_4CNS
Barium Carbonate	BaCO_3
Barium Chloride	BaCl_2

Barium Hydroxide	Ba(OH)_2
Barium Nitrate	$\text{Ba(NO}_3)_2$
Calcium Chloride	CaCl_2
Calcium Chloride Anhydrous	Ca(OH)_2
Calcium Sulphate	CaSO_4
Calcium Disulphide	CaS_2
Cupric Sulphate	CuSO_4
Dimethyl Glyoxine	$(\text{CH}_3)_2\text{C}_2(\text{NOH})_2$
Ether	$(\text{C}_2\text{H}_5)_2\text{O}$
Ferric Chloride	Fe_2Cl_6
Ferrous Sulphate	FeSO_4
Hydrochloric Acid	HCl
Hydrogen Sulphide	H_2S
Iodine Solution	I-I-KI
Lead Acetate	$\text{Pb(C}_2\text{H}_3\text{O}_2)_2$
Magnesium Sulphate	MgSO_4
Mercuric Chloride	HgCl_2
Mercuric Nitrate	$\text{Hg}_2(\text{NO}_3)_2$
Nitric Acid	HNO_3
Oxalic Acid	$\text{H}_2\text{C}_2\text{O}_4$
Phenol	$\text{C}_6\text{H}_5\text{OH}$
Picric Acid	$\text{C}_6\text{H}_2\text{OH(NO}_2)_3$
Platinic Chloride	PtCl_4
Potassium Carbonate	K_2CO_3
Potassium Chromate	K_2CrO_4

Potassium Dichromate	$K_2Cr_2O_7$
Potassium Ferricyanide	$K_3Fe(CN)_6$
Potassium Ferrocyanide	$K_4Fe(CN)_6$
Potassium Hydrate	KOH
Potassium Iodide	KI
Potassium Sulphate	K_2SO_4
Potassium Sulphocyanide	KCNS
Silver Nitrate	$AgNO_3$
Silver Sulphate	Ag_2SO_4
Sodium Acetate	$NaC_2H_3O_2$
Sodium Carbonate	Na_2CO_3
Sodium Hydroxide	NaOH
Sodium Phosphate	Na_2HPO_4
Sodium Thiosulphate	$Na_2S_2O_3$
Stannous Chloride	$SnCl_2$
Sulphuric Acid	H_2SO_4

CHAPTER VII

MISCELLANEOUS INFORMATION

Mineral Elements with their Symbols and
Combining Weights.

Name—	Symbol.	Combining Wt.
Aluminum	Al	27.1
Antimony	Sb	120.2
Argon	A	39.9
Arsenic	As	75
Barium	Ba	137.4
Beryllium	Be	9.1
Bismuth	Bi	208.5
Bromine	Br	79.96
Boron	B	11
Cadmium	Cd	112.4
Caesium	Cs	132.9
Calcium	Ca	40.1
Carbon	C	12
Cerium	Ce	140.25
Chlorine	Cl	35.45
Chromium	Cr	52.1
Cobalt	Co	59

Columbium	Cb	94
Copper	Cu	63.6
Erbium	Er	166
Fluorine	F	19
Gadolinium	Gd	156
Gallium	Ga	70
Germanium	Ge	72.5
Gold	Au	197.2
Helium	He	4
Hydrogen	H	1.008
Indium	In	114
Iodine	I	126.85
Iridium	Ir	193
Iron	Fe	55.9
Lanthanum	La	138.9
Lead	Pb	206.9
Lithium	Li	7.03
Magnesium	Mg	24.36
Manganese	Mn	55
Mercury	Hg	200
Molybdenum	Mo	96
Neodymium	Nd	143.6
Neon	Ne	20.
Nickel	Ni	58.7
Nitrogen	N	14.04

Osmium	Os	191
Oxygen	O	.6
Palladium	Pd	106.5
Phosphorus	P	31
Platinum	Pt	194.8
Potassium	K	39.15
Praseodymium	Pr	140.5
Radium	Ra	225
Rhodium	Rh	103
Rubidium	Rb	85.4
Ruthenium	Ru	101.7
Samarium	Sm	150
Scandium	Sc	44.1
Selenium	Se	79.2
Silicon	Si	28.4
Silver	Ag	107.93
Sodium	Na	23.5
Strontium	Sr	87.6
Sulphur	S	32.06
Tantalum	Ta	183
Terbium	Tb	160
Thallium	Tl	204.1
Thorium	Th	232.5
Thulium	Tm	171
Tin	Sn	119
Titanium	Ti	48.1

Tungsten	W	184
Uranium	U	238.5
Vanadium	V	51.2
Xenon	Xe	128
Ytterbium	Yb	173
Yttrium	Yt	89
Zinc	Zn	65.4
Zirconium	Zr	90.6

PHYSICAL CONSTANTS OF MINERALS

Mineral.	Specific Gravity.	Specific Heat.	Melting Point Degrees C.
Aluminum	2.56	0.212	625
Antimony	2.56	0.051	432
Arsenic	5.67	0.081	
Barium	3.75	0.047	1200
Bismuth	9.80	0.031	268
Cadmium	8.60	0.057	320
Caesium	1.88		26
Calcium	1.57	0.170	
Chromium	6.80	0.120	1515
Cobalt	8.50	0.110	1500
Copper	8.82	0.094	1054
Didymium	6.64	0.046	
Gold	19.32	0.032	1045
Indium	7.42	0.057	176

Iridium	22.12	0.033	1950
Iron (wrought)	7.86	0.110	1600
Lanthanium	6.20	0.045	
Lead	11.37	0.031	326
Lithium	0.59	0.941	180
Magnesium	1.74	0.250	750
Manganese	8.00	0.120	1245
Mercury	13.59	0.032	395
Molybdenum	8.60	0.032	395
Nickel	8.80	0.072	
Osmium	22.48	0.110	1484
Palladium	11.50	0.031	2500
Potassium	0.87	0.170	62
Rhodium	12.10	0.058	2000
Rubidium	1.52	0.077	38
Ruthenium	12.26	0.061	2000
Silver	10.53	0.056	961
Sodium	0.97	0.290	95
Strontium	2.54	0.074	
Tantalum	10.80		
Tellurium	6.25	0.047	528
Thallium	11.85	0.034	288
Thorium	7.70	0.028	
Tin	7.29	0.056	232
Titanium	11.18	0.130	3000
Tungsten	19.10	0.033	1700

Uranium	18.70	0.028	
Vanadium	5.50		
Zinc	7.15	0.094	419
Zirconium	4.15	0.066	

DEGREES

Redness begins at 525 C.

Dark Red begins at 700 C.

Cherry Red begins at 850 C.

Light Red begins at 900 C.

Yellow begins at 1100 C.

White begins at 1300.

Full White begins at 1500.

COLOR OF METALS

SILVER WHITE—Aluminum, Bismuth, Molybdenum, Nickel.

BLUISH WHITE—Antimony, Zinc.

TIN WHITE—Cadmium, Mercury, Tin, Platinum.

BLUISH—Lead.

LEAD GRAY—Arsenic.

GRAY—Uranium.

STEEL GRAY—Cobalt.

GRAYISH WHITE—Manganese.

RED—Copper.

YELLOW—Gold.

YELLOWISH—Didymium.

COLOR OF ORES

YELLOW—Native Gold, Bromyrite, Iodyrite, Chaleopyrite, Wulfenite, Vanadinite, Zinc Bloom, Zincite, Calomel, Marcasite, Greenockite, Cassiterite, Gummite, Autunite, Scheelite, Aeschynite, Corundum, Topaz, Argonite, Orpiment, Hatchetite, Amber, Sulphur.

BRASS YELLOW—Sylvanite, Krennerite, Chalcopyrite, Pyrite.

YELLOWISH—Embolite, Mendipite, Dysluite, Wavellite, Magnesite, Boracite, Gypsum, Colemanite, Calcite, Barite, Witherite, Mirabilite, Natron, Salmiak, Tellurite, Sassolite, Diamond.

BRONZE YELLOW—Calverite, Pyrrhotite.

YELLOWISH BROWN—Plumbogummite, Mimetite, Sphalerite, Gothite, Hatchettolite, Xenotime, Æschynite, Dysluite.

BROWN OR BROWNISH—Sternbergite, Domlykite, Plumbogummite, Stolzite, Pyromorphite, Mimetite, Vanadinite, Descloizite, Wurtzite, Smithsonite, Willemite, Cinnabar, Chromite, Limonite, Goethite, Columbite, Siderite, Wad, Triplite, Rhodochrosite, Eggo-

nite, Cassiterite, Rutile, Eleasite, Uranite, Hatchettolite, Hubnerite, Scheelite, Yttroc-
 erite, Fergusonite, Euxenite, Sipylite, Xeno-
 time, Æschynite, Monazite, Corundum,
 Chrysoberyl, Cryolite, Waverellite, Magnesite,
 Gypsum, Apatite, Aragonite, Dolomite, Bar-
 ite, Strontianite, Diamond, Ozocerite.

WHITE OR WHITISH—Sylvanite, Domeykite,
 Alaskaite, Mendipite, Anglesite, Cerussite,
 Sphalorite, Goslarite, Smithsonite, Zinc Bloom,
 Calamine, Magnolite, Scheelite, Cryolite, Al-
 unogen, Waverlite, Sellaite, Brucite, Magnes-
 ite, Epsomite, Boracite, Fluorite, Gypsum,
 Andydrite, Ulexite, Colemanite, Calcite,
 Chalk, Dolomite, Barite, Witherite, Celes-
 tite, Strontianite, Sylvite, Halite, Marabilite,
 Borax, Niter, Nitratine, Natron, Salmiak,
 Tellurite, Sassolite, Arsenolite, Valentinite
 Livingstonite, Diamond, Mallardite.

GRAY OR GRAYISH—Petzite, Nagyagite,
 Stromegerite, Domeykite, Frieslebenite, Me-
 laconite, Guetermanite, Zinkenite, Aikinite,
 Kobellite, Stolzite, Pyromorphite, Cerussite,
 Goslarite, Zinc Bloom, Linnacite, Smaltite,
 Gersdorffiite, Grunauite, Tiemannite, Ono-

frite, Calomel, Native Iron, Hematite, Triphylite, Stannite, Alunite, Periclasite, Brucite, Boracite, Ulexite, Colemanite, Strontianite, Halite, Nitratine, Salmiak, Valentinite, Tetradymite, Graphite.

SILVER-WHITE—Krennerite, Native Silver, Eucarite, Cobaltite, Grunauite, Arsenopyrite, Leucopyrite.

TIN-WHITE—Platinum, Altaite, Native Mercury, Native Tellurium, Native Arsenic, Native Antimony, Tetradymite.

LEAD-GRAY—Argentite, Hessite, Eucarite, Schirmerite, Chalcocite, Crookersite, Tennantite, Enargite, Native Lead, Galena, Clausthalite, Jamesonite, Alaskaite, Molybdenite, Stibnite, Livingstonite.

IRON-BLACK—Stephanite, Polybasite, Margyrite, Polyargyrite, Schirmerite, Tinnanite, Enargite, Franklinite, Menaseanite, Magnetite, Chromite, Columbite, Pyrolusite, Stannite, Graphite,

BLACK OR BLACKISH—Pyrargyrite, Bronzardite, Melanconite, Vauquelinite, Sphalerite, Wurtzite, Asbolite, Onofrite, Chromite, Wolframite, Columbite, Psilomelane, Wad, Cassiterite, Rutile, Eliasite, Uranite, Hubnerite, Samarskite, Fergusonite, Euxenite, Sipy-

lite, Æschynite, Spinel, Aragonite, Dolomite, Diamond, Gilsonite, Elaterite, Ozocerite, Asphaltum, Coal.

COPPER-RED—Native Copper, Bornite, Niccolite, Briethauptite, Pyrrhotite.

RED OR REDDISH—Pyrargyrite, Proistite, Pyrostiepnite, Cuprite, Minium, Crocoite, Melanochroite, Stolzite, Vanadinite, Sphalerite, Zincite, Willemite, Melonite, Erythrite, Cinnabar, Siderite, Rhodochrosite, Scheelite, Monazite, Corundum, Ruby, Garnet, Almandine, Eosphorite, Fluorite, Anhydrite, Celestite, Pealgar, Valentinite, Diamond.

BLUE—Cerargyrite, Cavellite, Chalcauthite, Cyanotrichite, Azurite, Linarite, Aurichalcite, Vicianite, Sapphire, Spinel, Lazulite, Turquoise, Fluorite, Anhydrite, Apatite, Diamond.

GREEN OR GREENISH—Cerargyrite, Bromyrite, Embolite, Atacamite, Brochantite, Olivine, Eichroite, Gerhardite, Malachite, Diopside, Chrysocolla, Vauquelinite, Stolzite, Descloizite, Willemite, Calamine, Zaratite, Genthite, Melanterite, Vivianite, Manganoite, Triphylite, Tobernite, Scheelite, Emerald, Spinel, Chrysoberyl, Amblygonite, Turquoise, Waverllite, Periclasite, Brucite, Boracite,

Fluorite, Apatite, Strontianite, Diamond,
VIOLET—Amethyst, Almandine.

Some ores, owing to slight differences in composition, assume a variety of colors. This will explain why a number of ores are listed under more than one color.

THE SILICATES

Included in the rock formations classified as silicates are many varieties having greater or less commercial value. Others which have no commercial value are liable to be suspected, by the prospector, of being ores, therefore to assist him in identification of such rocks, the following list is given:

WHITE OR WHITISH—Rock Crystal (quartz),
Milky Quartz, Opal, Hydrophane, Tridymite,
Tripolite, Enstatite, Wollastonite, Petalite,
Amphibole, Tremolite, Asbestos, Zoisite, Zircon, Jargon, Nephelite, Wernerite, Leucite, Anorthite, Andesite, Oligoclase, Microcline, Orthoclase, Lepidolite, Paragonite, Phlogopite, Muscovite, Enclase, Cyanite, Datolite, Pennitite, Ripidolite, Margarite, Thomsonite, Natrolite, Analcite, Chabazite, Harmotome, Stilbite, Heulandite, Talc, Prophyllite, Sepio-

tite, Deweytite, Saponite, Pectrolite, Laumonite, Apophyllite, Allophane, Kaolinite.

GRAY OR GRAYISH—Wood Opal, Tripolite, Enstatite, Spodumene, Petalite, Tremolite, Asbestos, Zoisite, Axinite, Zorcon, Epidote, Wernerite, Nephelite, Sodalite, Leucite, Anorthite, Labradorite, Andesite, Oligoclase, Albite, Paragonite, Fibrolite, Cyanite, Datolite, Titanite, Vermiculite, Margarite, Ontoritoid, Natrolite, Analcite, Harmotome, Heulandite, Sepiolite, Pectolite, Laumonite, Apophyllite, Pinite, Fahlunite, Flint, Cat's Eye.

YELLOW OR YELLOWISH—Quartz, Topaz, Aventurine, Opal, Fire Opal, Jasper, Enstatite, Wollastonite, Beryl, Zircon, Epidote, Nephelite, Paragonite, Astrophyllite, Phlogopite, Muscovite, Chondrodite, Datolite, Vermiculite, Natrolite, Harmotome, Stilbite, Gloaonite, Deweylite, Saponite, Laumonite, Allophane, Onyx, Dauburite.

GREEN OR GREENISH—Prase, Chrysoprase, Cat's Eye, Bloodstone, Spudomene, Petalite, Amphibole, Actinolite, Asbestos, Hornblend, Chrisolite, Zoisite, Vesuvianite, Epidote, Wernerite, Nephelite, Sodalite, Laboradorite, Oli-

goclase, Microline, Orthoclase, Cryophyllite, Muscovite, Biotite, Euclase, Cyanite, Topaz, Datolite, Penninite, Pochlorite, Talc, Pyrophyllite, Glauconite, Serpentine, Deweylite, Saponite, Phehnite, Allophane, Pinite, Fahlnite.

BLUE OR BLUISH—Amethyst, Opal, Beryl, Solite, Wernerite, Sodalite, Ultramarine, Andesite, Albite, Euclase, Cyanite, Topaz, Saponite, Allophane, Kaoline.

PURPLE—Amethyst.

VIOLET—Tremolite.

LILAC—Lepidolite, Kunzite

PINK—Rose Quartz.

RED OR REDDISH—Rose Quartz, Carnelian, Sard, Opal, Rhodonite, Garnet, Zircon, Hyacinth, Nephelite, Anorthite, Andesite, Oligoclase, Albite, Microcline, Lepidolite, Chondrodite, Andalusite, Pennite, Ripidolite, Margarite, Chabazite, Harmatome, Stilbite, Heulandite, Saponite, Laumonite, Kaolinite.

BROWN OR BROWNISH—Sard, Flint, Jasper, Wood Opal, Enstatite, Wollastonite, Chrysolite, Axinite, Zircon, Epidote, Wernerite, Sodalite, Labradorite, Phlogopite, Muscovite, Chondrodite, Tourmaline, Fibrolite.

Staurolite, Titanite, Hisingerite, Vermiculite, Harmatome, Stilbite, Heulandite, Deweylite, Allophane, Pinite.

BLACK—Touchstone, Wood Opal, Hornblend, Biotite, Tourmaline, Staurolite, Titanite, Hisingerite, Chloritoid.

CLASSIFICATION OF ORES

GOLD TELLURIDE MINERALS—Native Gold, Sylvanite, Calverite, Petzite, Nagyagite, Krennerite.

SILVER MINERALS—Native Silver, Argentine, Stromeyerite, Sternbergite, Hessite, Eucairite, Pyrargyrite, Proustite, Stephanite, Polybasite, Miargyrite, Bringniardite, Freieslebenite, Pyrostilpnite, Schirmerite, Cerargyrite, Bromyrite, Embolite, Iodyrite.

COPPER MINERALS—Native Copper, Chalcocite, Chalcopyrite, Covellite, Bornite, Crookesite, Domeykite, Tennantite, Tetrahedrite, Atacamite, Enargite, Cuprite, Melanconite, Chalcantite, Brochanite, Cyanotrichite, Olivenite, Euchroite, Gerhardtite, Malachite, Azurite, Dioptase, Chrysocolla.

ZINC MINERALS—Zincite, Goslarite, Smithsonite, Zinc Bloom, Aurichalcite, Willemite, Calamine, Franklinite.

COBALT AND NICKEL MINERALS—Linnaeite, Millerite, Smaltite, Cobaltite, Niccolite, Breithauptite, Gersdorffite, Grunauite, Melonite, Asbolite, Erythrite, Zaratite, Genthite.

LEAD MINERALS—Native Lead, Galena, Clausthalite, Altaite, Jamesonite, Guitermanite, Zinkenite, Alkinitite, Kobellite, Alaskaite, Meninite, Plumbogummite, Anglesite, Linarite, Crocoite, Melanochroite, Vauquelinite, Wulfenite, Stolzite, Pyromorphite, Mimetite, Vanadinite, Descloizite, Cerussite.

MERCURY MINERALS—Native Mercury, Cinnabar, Tiemannite, Onofrite, Coloradoite, Calomel, Magnolite.

IRON MINERALS—Native Iron, Pyrite, Marcasite, Pyrrhotite, Arsenopyrite, Leucopyrite, Hematite, Menaccanite, Magnetite, Chromite, Limonite, Gothite, Melanterite, Wolframite, Columbite, Vivianite, Siderite.

MANGANESE MINERALS—Manganosite, Pyrolusite, Psilomelane, Wad, Mallardite, Tripylite, Triplite, Rhodochrosite.

CADMIUM, TIN AND TITANIUM MINERALS—Greenockite, Eggonite, Stannite, Cassi-

terite, Rutile.

URANIUM AND TUNGSTEN MINERALS—

Gummite, Eliasite, Uraninite, Hatchettolite, Tobernite, Autonite, Wolframite, Hubnerite, Scheelite, Ferberite.

CERIUM, YTTERIUM, ERBIUM, LANTHANUM, DUDYMIUM MINERALS—

Ytticerite, Samarskite, Fergusonite, Euxenite, Sopylite, Xenotime, Æschynite, Monazite.

MAGNESIUM MINERALS—

Periclasite, Sel-laite, Beucite, Epsomite, Boracite.

CALCIUM MINERALS—

Fluorite, Gypsum, Anhydrite, Ulexite, Colemanite, Apatite, Calcite, Chalk, Aragonite, Dolomite.

BARIUM, STRONTIUM, POTASSIUM, SODIUM, AND AMMONIUM MINERALS—

Barite, Witherite, Celestite, Strontianite, Sylvite, Halite, Mirabilite, Borax, Niter, Nitratine, Natron, Salmiak.

ALUMINUM MINERALS—

Corundum, Sapphire, Ruby, Topaz, Emerald, Amethyst, Gibbsite, Spinel, Alamandine, Dysluite, Chrysoberyl, Cryolite, Alunogen, Alunite, Amblygonite, Lazulite, Turquoise, Eosphrite, Wavelite.

SULPHUR, TELLURIUM, BORON AND
MOLYBDENUM—Native Sulphur, Native
Tellurium, Tellurite, Molybdenite, Sassolite.

CARBON MINERALS—Gilsonite, Flaterite,
Ozocerite, Hatchettite, Amber, Asphaltum,
Bituminous Coal, Anthracite Coal, Cannel
Coal, Jet, Albertite.

ARSENIC, ANTIMONY, BISMUTH—Native
Arsenic, Orpiment, Realgar, Arsenolite, Na-
tive Antimony, Stibnite, Valentinite, Living-
stonite, Native Bismuth, Tetradymite, Dia-
mond, Graphite.



